

## Larval history of *Caridina longirostris* H. Milne Edwards

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### Abstract

Complete larval history of *Caridina longirostris* was studied by rearing them under controlled conditions. Eight distinct zoeal stages and one intermediate stage were distinguished during the development from first zoea to first post-larva, which required a minimum of 15 days duration. First post-larvae were reared for 173 days, by which time, majority of them had developed to adult stage. A brief description on the major transformations of the appendages during the development of first postlarva to adult stage is also provided. The salinity of the rearing medium varied from 6 to 10‰ and ambient temperature from 23 to 28°C.

### Introduction

Atyid prawns belonging to the genus *Caridina* H. Milne Edwards, 1837, are distributed widely in tropical and subtropical estuaries, mangrove swamps, freshwater lakes and high land streams. They form an important faunal component of these ecosystems. The larval descriptions of several species of *Caridina* are available (Daday, 1907; Gurney, 1927; Shen, 1939; Nair, 1949; Babu, 1963; Shokita, 1973; Chinnayya, 1974; Pillai, 1975; Lakshmi, 1975; Glaister, 1976; Jaliha, 1978; Benzie, 1982; Benzie and de Silva, 1983; Salmen, 1987; and Kadrekar and Sankolli, 1987). Present work deals with the study of the complete life history of *Caridina longirostris* H. Milne Edwards, by rearing them under captive conditions. This species is found in large numbers in Cochin backwaters when the salinity decreases during the months of September to December due to monsoon effect.

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### Material and methods

Taxonomic status of the present species, *Caridina longirostris* was studied using the adults collected from the wild as well as, those obtained through rearing under controlled conditions. A perusal of the literature on the taxonomy of this complex group reveals that the identification of the various species of the genus *Caridina* is rendered difficult due to the wide variation and inconsistency observed in the rostral formula, relative length and breadth of the different segments of the pereopods, nature of the telson and size of eggs in the berry. However, the details

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of the present material, when compared, agree well with those of *C. longirostris* provided by Holthuis (1965, 1969). Hence the identity of this species as *C. longirostris* was confirmed.

Adult animals for the experiments were collected from Cochin backwaters and transported to the laboratory in plastic containers, in water collected from the same locality. The size of the adult specimens ranged from 24 to 31 mm in total length and 8 - 12 mm in carapace length. The number of eggs in the berry varied from 435 to 1325. The eggs are small and oval measuring 0.35 to 0.45 mm in greatest length and 0.21 to 0.25 mm in greatest width. Salinity of the surface water at the collection centre varied from 6.8 to 18 ‰. Females with advanced stage of berry were sorted out from the collections and maintained individually in five litre glass containers containing filtered water of 6-10‰. Continuous mild aeration is provided. Hatching took place invariably during the early morning hours. After the completion of the hatching process, mother was removed from the container. It was observed that the mother prawn regularly moulted within 24 hours after the release of the berry. Freshly hatched zoeae were removed to rearing containers containing filtered water of 6-10‰ salinity and stocked at the rate of 30 to 40 larvae per litre and provided continuous mild aeration. Larvae were fed with mixed phytoplankton. Bottom sediments were not removed throughout the experiments, although one-third water was removed regularly and replaced with well aerated

water of the same salinity. Adequate quantity of mixed phytoplankton was added. Advanced zoeal stages were observed to feed on detritus.

For detailed morphological studies, the larvae and post larvae were preserved in 5% formaldehyde. The measurements of eggs and larvae were made from preserved materials using micrometer. The appendages were dissected out immersing in 5% formaldehyde using entomological needles, and drawings were made using camera lucida mounted on a monocular compound microscope. The total length of the zoeae was taken from the tip of the rostrum to the tip of telson excluding the terminal spines. The carapace length was measured from the tip of the rostrum to the mid dorsal point of the posterior margin of the carapace.

During the larval development of this species, eight distinct zoeal stages and one intermediate stage, during metamorphosis from first zoea to first postlarva were distinguished. The postlarvae were further reared for a period of 173 days. By this time they have metamorphosed to the adult stage. During the experiment the ambient temperature of the water varied from 23 to 28° C.

The following abbreviations are used in describing the larvae: A1-antennule; A2- antenna; Md- mandible; Mx1-maxillule; Mx2- maxilla; Mxp1- maxilliped I; Mxp2- maxilliped II; Mxp3- maxilliped III; P1- pereopod I; P2- pereopod II; P3- pereopod III; P4- pereopod IV; P5- pereopod V; PL.1 to PL.5- first pleopod to fifth

pleopod; T- telson; U- uropod; TL- total length; CL- carapace length.

### Description of larval stages

The salient features of the different zoeal stages as well as first post larva are given in Table 1.

Zoea I (Fig. 1): A1 (Fig. 1 b): Uniramous; peduncle long, unsegmented, carrying 2 flagella distally; inner flagellum is in the form of a long plumose seta, outer flagellum bears 3 aesthetes and 2 setae distally, of which one is slender, long, non-plumose and the other stout and plumose.

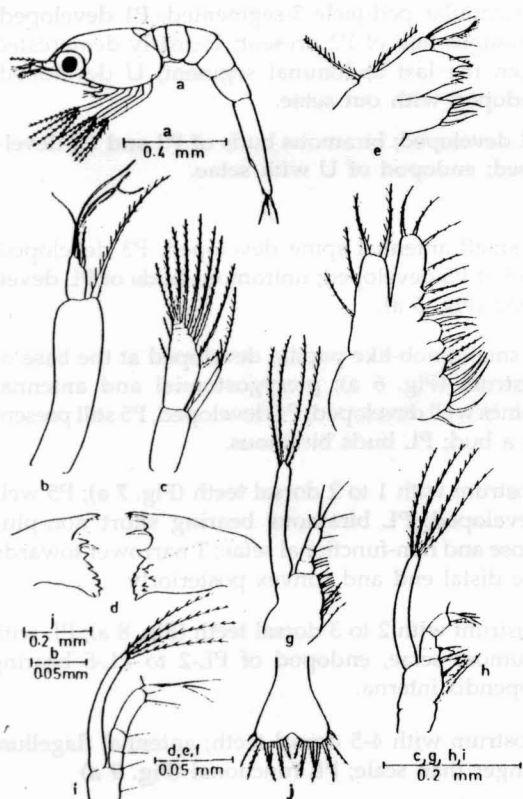


Fig. 1. *Caridina longirostris*: Zoea I: a- lateral view, b- A1, c- A2, d- Md, e- Mx1, f- Mx2, g- Mxp1, h- Mxp2, i- Mxp3, j- T.

A2 (Fig. 1 c): Biramous; peduncle short, unsegmented bearing a scale (exopod) and a flagellum (endopod) and has a long spine at its base; flagellum unsegmented, reaching more than half the length of the scale and carries distally one long plumose seta and 3 short non-plumose setae; scale with 4 distal segments and bears 10 setae along its inner and distal margin and 2 short plumose setae at its outer margin. Md (Fig. 1 d): Asymmetrical, without palps; incisor and molar processes differentiated; incisor process carries 2-3 teeth and molar process of both sides with a number of short stout teeth and with rough cutting edges; the 2 processes are separated by a shallow depression which bears 2 teeth of which one is slender and serrated. Mx1 (Fig. 1 e): Biramous; protopod unsegmented with 2 endites; distal endite (basal) with 5 short stout teeth of which one is serrated; proximal endite (coxa) with 5 long setae; palp (endopod) unsegmented bearing 4 apical setae of which 3 are long and slender, and another one stout bearing bristle-like setae and shows a characteristic tilt at its distal end; exopod is small carrying 2 long plumose setae. Mx2 (Fig. 1 f): Biramous; protopod unsegmented with 4 endites, 2 basal and 2 coxal; proximal coxal endite with 6 setae while others with 2 setae each, some of the setae being plumose; endopod unsegmented, reaches a little beyond the exopod, and bears 9 setae; exopod broad, flat (scaphognathite) with 4 long plumose setae along its margin. Mxp1 (Fig. 1 g): Biramous; coxa with 2-3 long plumose setae; basis broad, bearing

**Table 1.** *Caridina longirostris*: Salient features of different larval stages reared in the laboratory.

| Larval stage | Carapace Length (mm) Range (Mean) | Total Length (mm) Range (Mean) | Salient features   |
|--------------|-----------------------------------|--------------------------------|--|
| Zoea I       | 0.30-0.42 (0.398)                 | 1.23-1.36 (1.273)              | Eyes sessile; pterygostomial spine present (Fig.1a); antennular peduncle unsegmented; A1, A2, Md, Mx1, Mx2 and Mxp1 to Mxp3 developed; T with 7+7 spines and not demarcated from the last abdominal segment. |
| Zoea II      | 0.44-0.49 (0.458)                 | 1.48-1.54 (1.505)              | Eyes stalked; rostrum smooth (Fig. 2 a) antennular peduncle 2-segmented; biramous bud of P1 and P2 developed; T with 8+8 spines.   |
| Zoea III     | 0.52-0.56 (0.545)                 | 1.65-1.85 (1.736)              | Antennular peduncle 3-segmented; P1 developed; biramous bud of P2 present; T clearly demarcated from the last abdominal segment; U developed, endopod with out setae.  |
| Zoea IV      | 0.56-0.59 (0.574)                 | 1.88-2.02 (1.963)              | P2 developed; biramous buds of P3 and P4 developed; endopod of U with setae.   |
| Zoea V       | 0.63-0.70 (0.659)                 | 2.09-2.34 (2.237)              | A small antennal spine developed; P3 developed, bud of P5 developed; uniramous buds of PL developed (Fig. 5 a).  |
| Zoea VI      | 0.62-0.67 (0.638)                 | 2.30-2.44 (2.354)              | A small knob-like papilla developed at the base of rostrum (Fig. 6 a); pterygostomial and antennal spines well developed; P4 developed, P5 still present as a bud; PL buds biramous.                         |
| Zoea VII     | 0.77-0.87 (0.825)                 | 2.72-3.04 (2.916)              | Rostrum with 1 to 2 dorsal teeth (Fig. 7 a); P5 well developed; PL biramous bearing short non-plumose and non-functional setae; T narrower towards the distal end and convex posteriorly                     |
| Zoea VIII    | 0.81-0.99 (0.889)                 | 2.91-3.30 (3.093)              | Rostrum with 2 to 3 dorsal teeth (Fig. 8 a); PL with plumose setae, endopod of PL-2 to PL-5 bearing appendix interna.  |
| Intermediate | 0.91-1.01 (0.956)                 | 2.67-3.25 (3.037)              | Rostrum with 4-5 dorsal teeth; antennal flagellum longer than scale; PL functional (Fig. 9 a)  |
| Postlarva I  | 1.72-1.75 (1.740)                 | 4.72-4.91 (4.835)              | Rostrum with 6-8 dorsal and 2-4 ventral teeth (Fig. 10 a); exopod of pereopod absent or rudimentary and non-functional.  |

9-10 setae; exopod longer than endopod carrying distally 4 long plumose setae; endopod 4-segmented, distal segment with 4 setae, proximal with 3 and other segments with one seta each. Mxp2 (Fig. 1 h): Biramous; coxa with one and basis with 7-8 setae; exopod longer than endopod, bearing distally 4 long plumose setae; endopod 4-segmented; distal segment with 4 setae along the apical and sub-apical region, third segment with 2 long setae, of which one is plumose, first segment bearing 2 setae on the inner distal margin. Mxp3 (Fig. 1 i): Biramous; protopod with 2 slender setae; exopod bearing 4 long plumose setae distally and one short seta sub-epically; endopod 4-segmented, distal segment bearing 4 setae, of which one is very short, first, second and third segments with 1, 1 and 2 setae respectively along the inner margin. T (Fig. 1 j): Broadly triangular with a median notch on the posterior margin, dividing telson into two symmetrical lobes, each carrying 7 plumose setae.

Zoea II: A1 (Fig. 2 b): Peduncle 2-segmented; anterodorsal surface of the distal segment with a small prominence (antennular lobe) carrying 2 short plumose setae; inner flagellum seen as a small lobe with a long plumose seta; outer flagellum bears 4 long aesthetes and one short slender seta. A2 (Fig. 2 c): Flagellum half the length of scale, carrying one long plumose seta and another short seta at its distal end. Md (Fig. 2 d): Incisor with 3-4 teeth; 2-3 serrated teeth present in between the incisor and molar processes. Mx1 (Fig. 2 e): Distal end of protopod

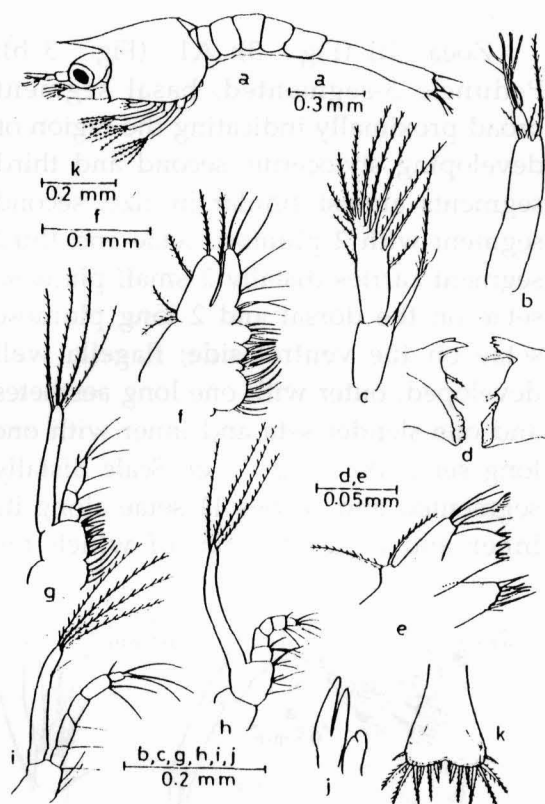


Fig. 2. *Caridina longirostris*: Zoea II: a- lateral view, b- A1, c- A2, d- Md, e- Mx1, f- Mx2, g- Mxp1, h- Mxp2, i- Mxp3, j- bud of P1 and P2, k- T.

with 6-7 teeth. Mx2 (Fig. 2 f): Coxal endite with 7+3 and basal endite with 3+5 setae; exopod with 5 long plumose setae. Mxp1 (Fig. 2 g): Few setae along the inner margin of the protopod have become longer. Mxp2 (Fig. 2 h): Endopod 5-segmented. Mxp3 (Fig. 2 i): Protopod with 3 long slender setae along the inner margin; endopod 5-segmented. Pereiopods (Fig. 2 j): P1 and P2 developed as biramous buds, of which P2 is smaller. T (Fig. 2 k): Each lobe of T with 8 setae, outermost seta plumose on the inner side and other setae plumose on both sides.



Zoea III (Fig. 3): A1 (Fig. 3 b): Peduncle 3-segmented; basal segment broad proximally indicating the region of developing stylocerite, second and third segments almost similar in size, second segment with 2 plumose setae and third segment carries distally 2 small plumose setae on the dorsal and 2 long plumose setae on the ventral side; flagella well developed, outer with one long aesthetes and one slender seta and inner with one long seta. A2 (Fig. 3 c): Scale distally segmented and carries 11 setae along its inner and distal margin, of which the

distolateral seta on the outer margin small and spine like. Mx1 (Fig. 3 e): Distal endite with 8-9 stout teeth; exopod with 2 plumose setae. Mx2 (Fig. 3 f): Exopod with 8 long plumose setae. Mxp3 (Fig. 3 i): Protopod bearing 3 long slender setae on the inner side; first segment of endopod with 2 long slender setae at the distal inner margin. P1 (Fig. 3 j): Biramous; protopod with 2 setae at the inner margin; exopod as long as endopod bearing distally 4 long plumose setae and one sub-apical seta; endopod 5-segmented, distal segment with 3 long setae and one short seta, second and fourth segments carry 2 long setae at the distal inner margin, first segment bearing one seta on the distal margin. U (Fig. 3 k): Biramous; endopod bare and exopod with 6 plumose setae. T (Fig. 3 k): Each lobe with 7 plumose setae and one distolateral spine; the median notch has become shallow.

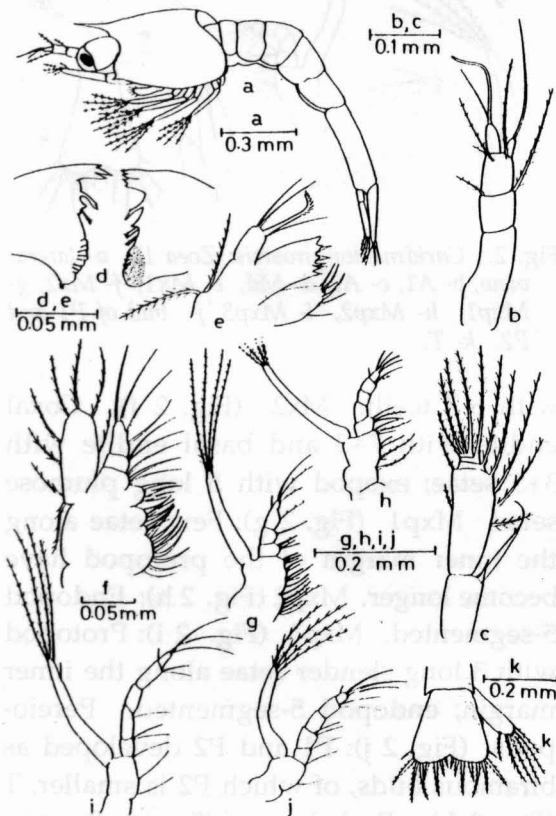


Fig. 3. *Caridina longirostris*: Zoea III: a- lateral view, b- A1, c- A2, d- Md, e- Mx1, f- Mx2, g- Mxp1, h- Mxp2, i- Mxp3, j- P1, k- T & U.

Zoea IV (Fig. 4): A1 (Fig. 4 b) The proximal segment of the peduncle slightly bulged bearing a short plumose seta, a stout spine present on the ventral side of this segment; distal region of the first and second segments with 2 setae each; outer flagellum with 2 aesthetes and one long slender non-plumose seta. A2 (Fig. 4 c): Distal part of the scale with out segments and the scale carries 13 plumose setae and one distolateral spine at the outer margin; endopod about  $\frac{2}{3}$ <sup>rd</sup> of exopod bearing apically one sigmoid non-plumose seta. . Mx1: Exopod absent; distal endite with 7-9 stout teeth and proximal endite with 6-7 long setae. Mx2 (Fig. 4 d): Number of setae on the endite of protopod

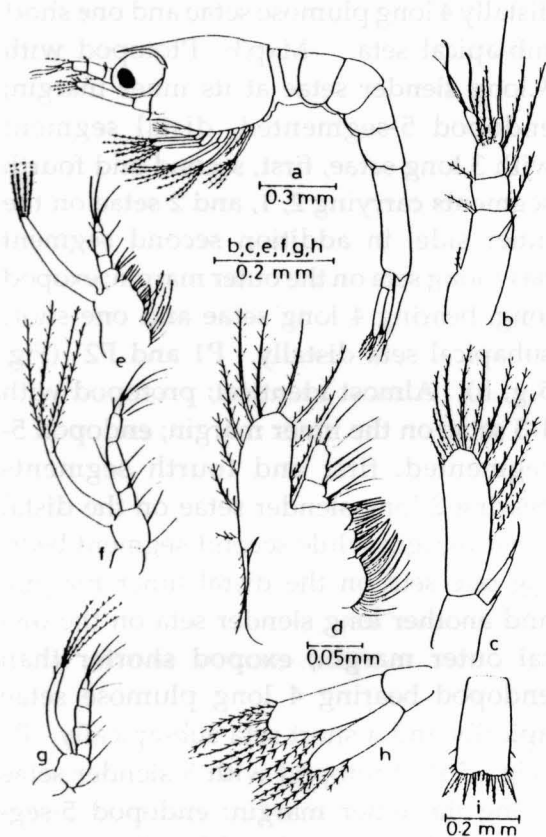


Fig. 4. *Caridina longirostris*: Zoea IV: a- lateral view, b- A1, c- A2, d- Mx2, e- Mxp1, f- P1, g- P2, h- U, i- T.

increased; exopod with 12 long plumose setae; a short proximal projection bearing one plumose seta developed at the proximal outer part of the scaphognathite. Mxp1 (Fig. 4 e): Proximal segment of protopod with 7-8 long setae of which some are plumose; basis with 14 setae; endopod 4-segmented, second segment bearing one plumose seta at the distal outer margin, distal segment with 3 long setae and one small sub-apical seta. P2 (Fig. 4 g): Basis of protopod with 2-3

setae; endopod 5-segmented with 3 long setae apically, first and fourth segments bear 2 setae at the distal inner margin, while the second segment has one seta on the inner distal margin; exopod as long as the endopod bearing 4 long plumose setae apically and one short seta subapically. U (Fig. 4 h): Exopod with 9-10 plumose setae and one short spine; endopod with 6 plumose setae. T (Fig. 4 i): Longer and narrower and the median notch has become shallower than in the previous stage, each lobe bearing 5 setae of which the outer most one plumose only on the inner side, distolateral margin bears 3 short spines on either side of the telson.

Zoea V (Fig. 5): A1 (Fig. 5 b): Peduncle 3-segmented, proximal segment has a broad stylocerite with 2 short plumose setae, antennular lobe of third segment with short plumose setae and the same segment on the ventral side carries 4 long plumose setae; inner flagellum as long as the outer, carrying a long slender seta, outer flagellum with 2 aesthetes and 2 long slender setae. A2 (Fig. 5 c): Scale with 15 plumose setae and one spine; flagellum unsegmented less than half the length of scale bearing a short sickle shaped seta at its apex. Md (Fig. 5 d): Incisor with 4 teeth and molar with a number of short teeth and rough cutting edges, in between the two processes 2-4 serrated teeth present. Mx1 (Fig. 5 e): Basal endite of protopod with 9 teeth and coax with 7-8 setae. Mx2 (Fig. 5 f): Distal 2 endites of protopod bearing 5-7 setae; third endite carries 2-3 setae and proximal endite with 10-13 plumose se-

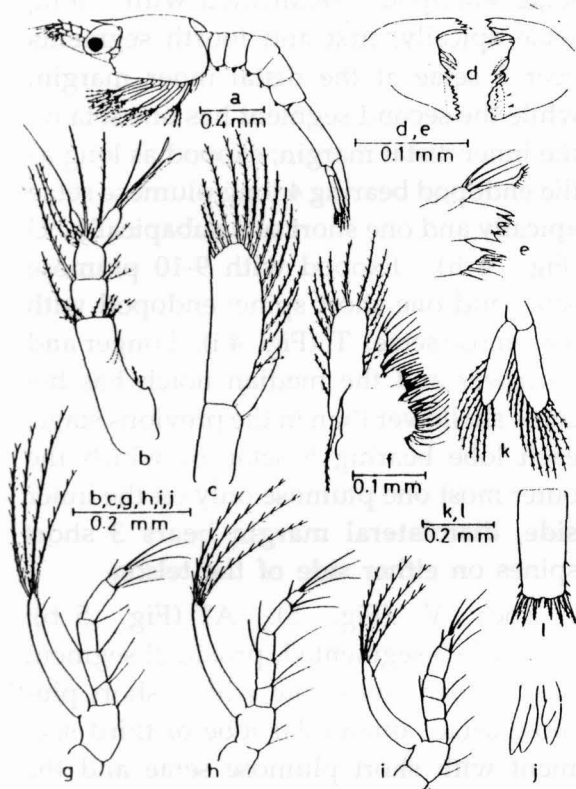


Fig. 5. *Caridina longirostris*: Zoea V: a- lateral view, b- A1, c- A2, d- Md, e- Mx1, f- Mx2, g- P1, h- P2, i- P3 j- biramous bud of P4 & P5, k- U, l- T.

tae; exopod with 16-17 plumose setae. Mxp1: Proximal endite of protopod with 5-6 long setae of which some are plumose; distal endite with 14-15 setae; endopod 4-segmented, first and fourth segments bearing 3 setae each and the other two with one seta on the inner side, in addition, second and fourth segments also carry one seta at its outer margin; exopod with 4 long plumose setae apically. Mxp2: Coxa and basis with 2 and 8-10 setae on the inner margin; endopod 5-segmented; exopod longer than endopod, bearing

distally 4 long plumose setae and one short sub-apical seta. Mxp3: Ptotopod with 3 long slender setae at its inner margin; endopod 5-segmented, distal segment with 3 long setae, first, second and fourth segments carrying 2, 1, and 2 setae on the inner side, in addition second segment has a long seta on the outer margin; exopod long, bearing 4 long setae and one short subapical seta distally. P1 and P2 (Fig. 5 g, h): Almost identical; protopod with 1-3 setae on the inner margin; endopod 5-segmented, first and fourth segments bearing 2 long slender setae on the distal inner margin while second segment bearing one seta on the distal inner margin, and another long slender seta on the distal outer margin; exopod shorter than endopod bearing 4 long plumose setae apically and a short seta sub-apically. P3 (Fig. 5 i): Protopod with 3 slender setae along the inner margin; endopod 5-segmented, first, second and fourth segments carrying 1, 2 and 2 setae respectively, distal segment with 3 setae at its apex and a short seta sub-apically; exopod shorter than endopod bearing distally 4 long plumose setae. P4 & P5 (Fig. 5 j): Seen as biramous buds. U (Fig. 5 k): Exopod with 12 plumose setae and one non-plumose seta; endopod with 9 plumose setae. T (Fig. 5 l): Almost rectangular, the median depression at the posterior boarder much reduced and each lobe carries 5 plumose setae of which the outer one being plumose only on the inner side. Telson bearing 3 spines each on either side on the distolateral margin

Zoea VI (Fig. 6): A1 (Fig. 6 b): Distal



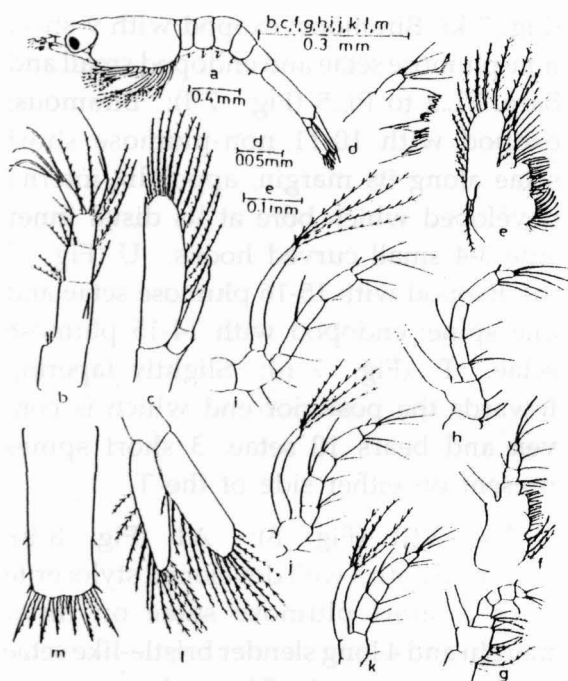


Fig. 6. *Caridina longirostris*: Zoea VI: a- lateral view, b- A1, c- A2, d- Mx1, e- Mx2, f- Mxp1, g- Mxp2, h- Mxp3, i- P1 j- P3, k- P4, l- U, m- T.

segment bears 5 long plumose setae along the ventral side anteriorly; inner flagellum with 2 setae of which one is long and slender, outer flagellum carries 3 aesthetes and one long slender seta. A2 (Fig. 6 c): Exopod narrower than that of the previous stage and endopod segmented. Mx1 (Fig. 6 d): Basal endite with 10-11 teeth and coax with 8-9 setae. Mx2 (Fig. 6 e): Exopod with 18 setae. P3 & P4 (Fig. 6 j, k): Almost identical; endopod 5-segmented, distal segment with 3 long setae, first and fourth segments carry 2 slender long setae along the distal inner margin, second segment with 2 setae at its distal margin; exopod shorter than the endopod bearing 4 long plumose apical setae and

one short sub apical seta. Pleopods developed as biramous buds. U (Fig. 6 l): Exopod with 13 plumose setae and one non-plumose seta; endopod with 10-11 plumose setae

Zoea VII (Fig 7): A1 (Fig. 7 b): Number of short plumose setae along the anterior margin of first and second segments increase; distal segment carries ventrally 6 long plumose setae, inner flagellum longer than outer, indistinctly segmented carrying one long and 2 short slender setae

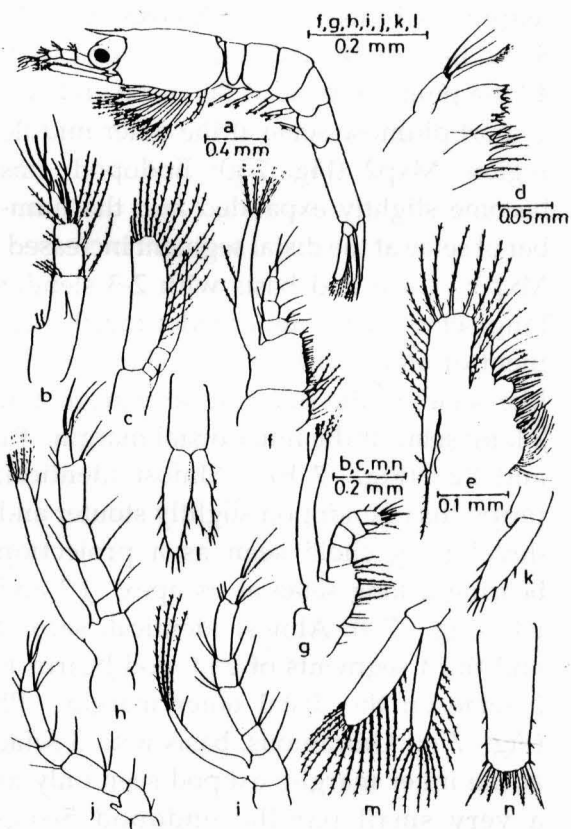


Fig. 7. *Caridina longirostris*: Zoea VII: a- lateral view, b- A1, c- A2, d- Mx1, e- Mx2, f- Mxp1, g- Mxp2, h- P1, i- P3, j- P5, k- PL.1, l- PL.2, m- U, n- T.

distally; outer flagellum with one long seta and 5 aesthetes in two rows of 3 and 2. A2 (Fig. 7 c): Scale with 16-17 long plumose setae and one spine; flagellum 3-4 segmented bearing at its apex 3-4 short setae. Mx1 (Fig. 7 d): Coxal endite has become more broader bearing 10-11 setae of which some are plumose. Mx2 (Fig. 7 e): Number of setae on the endite increased; exopod with 23-24 plumose setae and its posterior lobe elongated. Mxp1 (Fig. 7 f): Coxa and basis more flattened and the number of setae on the inner margin of basis increased, coxa bears 7-8 and basis with 22-23 setae; exopod with 4 long plumose setae at the distal end and 2 short plumose setae at the outer middle region. Mxp2 (Fig. 7 g): Endopod has become slightly expanded and the number of setae at the distal segment increased. Mxp3: Coxa and basis with 2-3 slender long setae on the inner side; fourth segment of endopod bearing 2 short bristle-like setae on the outer distal margin and 2 long setae at the inner distal margin. P1 and P2 (Fig. 7 h): Almost identical; propodus of endopod slightly stouter and developing chela seen as a projection bearing 2 long setae at its apex. P3 and P4 (Fig. 7 i): Almost identical; second and third segments of endopod bear 1-2 setae on the distal outer margin. P5 (Fig. 7 j): Uniramous, basis with 3 setae at the inner margin; exopod seen only as a very small papilla; endopod 5-segmented, first, second and third segments bearing 2 setae each and fourth segment bears 3 setae, distal segment carrying 3 setae distally of which one is stout. PL.1

(Fig. 7 k): Biramous; exopod with 9 short non-plumose setae and endopod small and bare. PL.2 to PL.5 (Fig. 7 l): Biramous; exopod with 10-11 non-plumose short setae along its margin, appendix interna developed which bore at its distal inner side 3-4 small curved hooks. U (Fig. 7 m): Exopod with 15-16 plumose setae and one spine; endopod with 14-15 plumose setae. T (Fig. 7 n): Slightly tapering towards the posterior end which is convex and bears 10 setae, 3 short spines present on either side of the T.

Zoea VIII (Fig. 8): A1 (Fig. 8 b): Peduncle with a well developed stylocerite with 3 short plumose setae on inner margin and 4 long slender bristle-like setae on the outer margin; 7 long plumose setae present at the anterior ventral side of the third segment; inner flagellum segmented; outer flagellum with 6 aesthetes in two rows of 3 each. A2 (Fig. 8 c): Scale bearing 20 long plumose setae and one spine; flagellum longer than scale and 5-7 segmented. Md (Fig. 8 d): 3-6 teeth present in between incisor and molar processes. Mx1 (Fig. 8 e): More flattened than in the previous stage and coxopodite with 10-11 setae, which are serrated. Mx2 (Fig. 8 f): Exopod with 28-30 plumose setae and its posterior lobe elongated. Mxp1 (Fig. 8 g): Segmentation between third and fourth segment indistinct. Mxp2 (Fig. 8 h): Distal segments of endopod expanded, the distal segment carries 9 short setae at its distal and outer regions. Mxp3: Endopod slightly bent towards the inner side, fourth segment bearing 2 short bristle-like setae at the middle re-

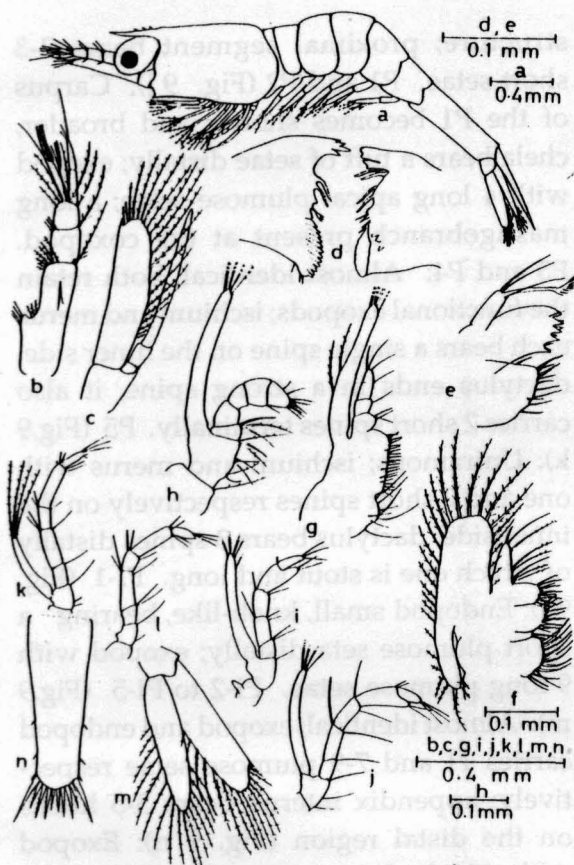


Fig. 8. *Caridina longirostris*: Zoea VIII: a- lateral view, b- A1, c- A2, d- Md, e- Mx1, f-Mx2, g- Mxp1, h- Mxp2, i- P1, j-P2, k-P3, l-P5, m- U, n-T.

gion; exopod shorter than endopod. P1 and P2 (Fig. 8 i, j): Developing chela of propodus more pronounced; propodus of P2 slightly longer than that of P1. P3 (Fig. 8 k) and P4: Propodus with 2 short setae, dactylus of endopod bearing one stout spine at its apex, it also carries 2 setae and a short spine, fourth segment carries distolaterally 4-6 setae, second and third segment carry 3 setae; exopod as long as the first 2 segments of endopod, bearing 4 plumose setae at its distal end. P5 (Fig. 8 l): Uniramous; dactylus with

a stout spine distally, it also bears one short spine and 2 setae, first, second third and fourth segments carry distolaterally 2, 3, 3 and 4 setae. Pleopods bear plumose setae and are functional; exopod with 10-11 setae and endopod of second to fifth pleopods with 6 setae, appendix interna bears 4-6 hook. U (Fig. 8 m): Exopod with 16-17 plumose setae and 1-2 spines; endopod with 16 plumose setae. T (Fig. 8 n): Distal part is highly convex bearing 10 stout setae and laterally it bears 3 spines on either side.

Intermediate stage (Fig. 9): A1 (Fig. 9 b): Inner flagellum longer than the outer and 4-segmented; outer flagellum 4-segmented bearing 5 aesthetes in two groups of 3 and 2 each. A2 (Fig. 9 c): Scale bearing 20 plumose setae and one spine; flagellum two times longer than scale bearing 12-13 segments. Md (Fig. 9 d): Asymmetrical; incisor process bearing 4-6 teeth; molar partially demarcated; in between the 2 processes 2-7 teeth present. Mx1 (Fig. 9 e): Coxa more flattened with 11 setae and basipod with 12-13 short teeth; endopod short, unsegmented bearing 2 short setae at its distal end. Mx2 (Fig. 9 f): Endopod unsegmented without setae; endites of basipod and coxopod have become more flattened; proximal lobe of exopod more pronounced bearing 6 short setae and devoid of the single long plumose seta which was present till the last zoeal stage, distal part carrying 19-20 plumose setae. Mxp1 (Fig. 9 g): Basis and coxa expanded and beset with 25-27 and 5-7 setae respectively; endopod slightly expanded at its basal region, bears

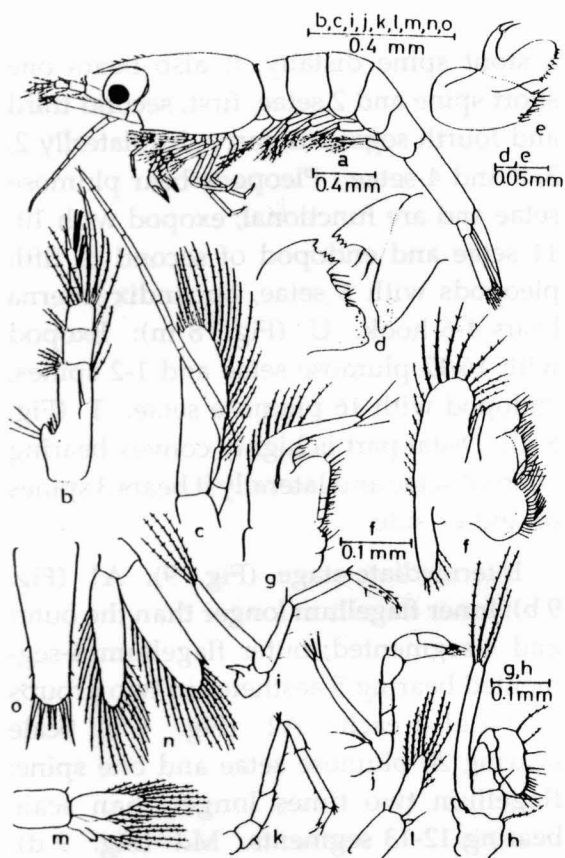


Fig. 9. *Caridina longirostris*: Intermediate stage: a- lateral view, b- A1, c- A2 d- Md, e- Mx1, f- Mx2, g- Mxp1, h- Mxp2, i- Mxp3, j- P1, k- P5, l- PL.1, m- PL.2, n- U, o- T.

8 plumose setae along its outer margin and shows the characteristic bent, right angles to the basipod and terminally bears 4 short non-plumose setae. Mxp2 (Fig. 9 h): Segmentation between the dactylus and propodus lost and together they form a flattened segment bearing 13-15 short setae of which some are plumose, this segment is as long as the first three segments of endopod and forms an 'U' shape. Mxp3 (Fig. 9 i): Ischium and merus as well as prodopod and dactylus of the endopod coalesced to form 3-segmented

structure; proximal segment bears 2-3 short setae. P1 and P2 (Fig. 9 j): Carpus of the P1 becomes shorter and broader, chela bears a tuft of setae distally; exopod with 4 long apical plumose setae; a long mastigobranch present at the coxopod. P3 and P4: Almost identical, both retain the functional exopods; ischium and merus each bears a single spine on the inner side, dactylus ends in a strong spine, it also carries 2 short spines terminally. P5 (Fig. 9 k): Uniramous; ischium and merus with one and 2 short spines respectively on the inner side, dactylus bears 3 spines distally of which one is stout and long. P1-1 (Fig. 9 l): Endopod small, knob-like, bearing a short plumose seta distally; exopod with 9 long plumose setae. P1-2 to P1-5 (Fig. 9 m): Almost identical; exopod and endopod carries 11 and 7-9 plumose setae respectively; appendix interna bears 3-5 hooks on the distal region (Fig. 9 n): Exopod with 16-18 plumose setae and a spine, development of diaeresis observed for the first time at this stage and it bears a spine; endopod with 18 plumose setae. T (Fig. 9 o): Tapers posteriorly, distal margin convex bearing 4 pairs of spines of which the lateral ones are the shortest, distal lateral half of the telson bearing 2 spines on either side.

Post larva I (Fig. 10): A1: 3-segmented peduncle, stylocerite well developed, distal segment carrying 7 long plumose setae on the ventral side, distally and 5 short plumose setae on a prominence on the dorsal side; flagellae are 6-7 segmented, outer flagellum carried 4 aesthetes in two groups of 2+2 (Fig. 10 b).



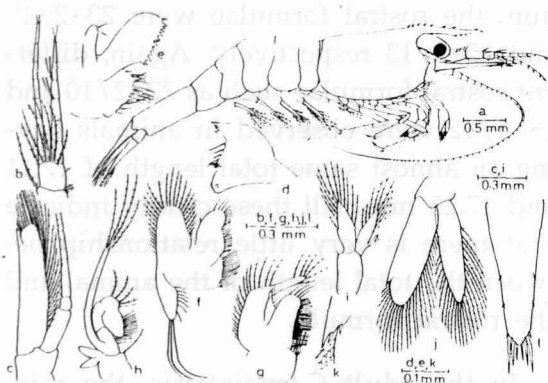


Fig. 10. *Caridina longirostris*: Postlarva I: a- lateral view, b- flagellum of A1, c- A2, d- Md, e- Mx1, f- Mx2, g- Mxp1, h- Mxp2, i- PL.2, j- U, k- diaeresis, l- T.

A2 (Fig. 10 c): Scale with 26-28 plumose setae, flagellum segmented and 4.0 to 5.5 times longer than scale. Md (Fig. 10 d): Molar process further demarcated. Mx1 (Fig. 10 e): Proximal mastigatory process flattened, becomes more or less semicircular in shape with 15-18 setae along its inner margin; basipod becomes broader distally bearing 15-16 short teeth; endopod short, bears 2 distal setae. Mx2 (Fig. 10 f): Number of setae on the protopodal endites increased; proximal part of the exopod produced, more flattened and bears 9-10 setae, of which the distal 3 are longer, distal part of the exopod with 26-27 plumose setae. Mxp1 (Fig. 10 g): Protopod further flattened; basal portion of exopod too flattened, possessing 17 plumose setae along its outer margin, distally exopod carries 6-7 plumose setae. Mxp2 (Fig. 10 h): Number of setae on the distal endopodal segment increased. P-1 (Fig. 11 a): Exopod palp-like, much reduced and bears 4 non-plumose short

setae, chela well developed, the ratio between the length/breadth of chela is 1.7 and that of length/breadth of carpus 1.35. P-2 (Fig. 11 b): Exopod reduced and non functional as in the P-1; ratio between length/breadth of carpus and chela is 2.86 and 1.92 respectively; a mastigobranch present on the exopod. P-3 (Fig. 11 c) and P-4: Almost identical, uniramous; dactylus carries 2 spines. P-5 (Fig. 11 d): Uniramous; dactylus bearing 5+1 spines. PL-1 (Fig. 11 e): Exopod with 11-12 plumose setae; endopod short, knob-like and bears 3 plumose setae. PL.2 to PL.5 (Fig. 10 i): Exopod and endopod each with 10-15 plumose setae; appendix interna possesses 4-5 hooks. U (Fig. 10 j):

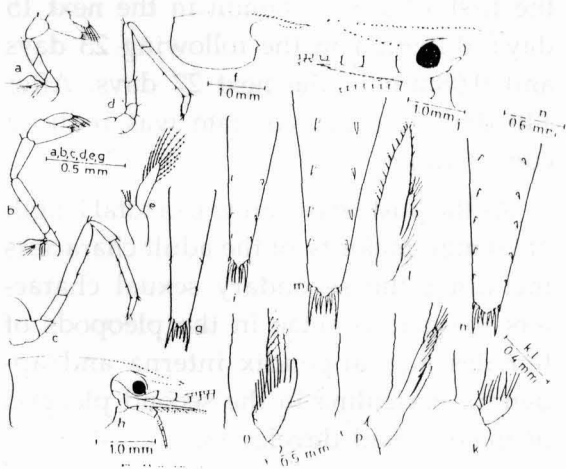


Fig. 11. *Caridina longirostris*: Postlarva I: a- P1, b- P2, c- P3, d- P5, e- PL.1. Specimen of TL 5 to 6 mm: f- carapace, g- T. Specimen of TL 7.6 mm: h- carapace, i- T. Specimen of TL 14 mm: j- rostrum and anterior part of carapace, k- endopod of PL.1, l- endopod of PL.2, m- T. Specimen of TL 23 mm: n- T. Specimen of TL 17 mm: o - endopod of PL.1, p- appendix interna and appendix masculina.



Exopod with 27-28 plumose setae and one spine; endopod with 24-26 plumose setae; diaeresis with 2 spines (Fig. 10 k). T (Fig. 10 l): With 2 pairs of short lateral spines and 4 pairs of spines at the distal end, posterior region further tapers, but without a median spine.

### Development of postlarva

The first postlarvae were further reared in the same container for 173 days and the important changes observed during the course of development are presented in Table 2.

A gradual increase in the size of postlarvae was obtained during a period of 140 days. The growth rate of postlarvae per day was observed to be 0.117mm in the first 72 days, 0.06mm in the next 15 days, 0.169mm in the following 23 days and 0.08mm in the next 27 days. After 140 days, the growth rate was reduced considerably.

As the post larvae grew to a total length of 20 mm, majority of the adult characters including the secondary sexual characters- ovigerous setae in the pleopods of females and appendix interna and appendix masculina in the second pleopod of males - had developed.

During the development of postlarvae, differences in the mode of development of rostral spines, from specimen to specimen and even among specimens belonging to the same brood was observed. The rostral formulae of animals of 23.6 and 24.4 mm total length were 18+1/12 and 19+1-2/15-16 respectively. But in some specimens having a total length of 14.15 and 15.13

mm, the rostral formulae were 23+2/10 and 22+2/13 respectively. Again, different rostral formulae such as 22+2/10 and 18+1/12 were observed in animals having an almost same total length of 17.11 and 17.25 mm. All these clearly indicate that there is very little relationship between the total length of the animal and the rostral formula.

In the adult *C. longirostris*, the ratio between the length and breadth of carpus of the first pereopod is 1.7 to 3.0 and of second pereopod 4.3 to 6.0. The ratio between the length of propodus and dactylus is 4.5 to 5.5 for third pereopod and 3.7 to 5.0 for fifth pereopod (Holthuis, 1969). These relationships, except in the case of third pereopod, were obtained in the laboratory reared animals of total length 17.25 mm. For third pereopod, the ratio was obtained when the animal reached a total length of 23.3mm.

Telson of the adult *C. longirostris* tapers to a median spine. Telson carried 4+4 posterior spines and 4+4 dorsal spinules. In the laboratory reared animals, the median spine was absent in the first postlarva, although the telson carried 4+4 distal spines and 2+2 dorsal spinules. The median distal spine appeared for the first time when the animal grew to a size of 5.3 to 6.2mm. At this stage the telson carried 3+3 dorsal spinules. The number increased to 4+4 only when the animal attained a total length of 14.15mm. Holthuis (1969) observed that this species generally carried 3 to 4 pairs of dorsal spines on the telson. But, during the

Table 2. *Caridina longirostris*: Important changes during the development of postlarvae.

| No. of days after becoming postlarva first | Carapace length (mm) range (mean) | Total length (mm) range (mean) | Salient features  |
|--|-----------------------------------|--------------------------------|---|
| First post-larva                           | 1.72-1.75<br>(1.740)              | 4.72-4.91<br>(4.835)           | Rostrum with 6-8 dorsal and 2-4 ventral teeth; rostrum not exceeding scaphocerite; exopods of pereopods absent or rudimentary and non-functional.   |
| 3  | 2.06-2.41<br>(2.178)              | 5.45-6.17<br>(5.825)           | Rostrum with 11 dorsal and 5 ventral teeth (Fig. 11. f); pterygostomial spine not as well developed as antennal; distal median spine of telson developed; telson with 4 pairs of distal and 2 pairs of distolateral spines (Fig. 11 f)  |
| 7  | 2.06-2.87<br>(2.31)               | 4.56-7.83<br>(6.17)            | Rostrum with 15-16+1 dorsal and 7-8 ventral teeth, there is a distinct unarmed portion behind the sub-apical tooth; pterygostomial spine absent, lower orbital angel well developed bearing a strong antennal spine; telson with 4 pairs of distal and 3 pairs of distolateral spines (Fig. 11 i)                   |
| 41   | 2.91-4.23<br>(3.45)               | 7.71-10.34<br>(9.11)           | ...   |
| 75   | 4.11-5.47<br>(4.69)               | 12.03-15.19<br>(13.64)         | ...   |
| 81   | 4.09-5.59<br>(4.85)               | 12.31-15.26<br>(13.96)         | ...   |
| 90   | 4.70-5.69<br>(5.11)               | 13.35-15.89<br>(14.57)         | Telson with 4 pairs of spines distally and 4 pairs of short spines on the dorsal side towards lateral margin (Fig. 11 m) appendix masculine developed on the second pleopod (Fig. 11. l), appendix interna on first pleopod not developed (Fig. 11 k ).   |
| 113  | 5.40-7.99<br>(6.69)               | 15.13-21.81<br>(18.47)         | ...   |
| 140  | 5.83-8.46<br>(7.31)               | 17.53-24.44<br>(20.73)         | Endopod of first pleopod of male with appendix interna (Fig. 11 o); appendix masculine present on the second pleopod (Fig. 11 p).   |
| 173  | 5.69-8.6<br>(7.16)                | 17.11-23.26<br>(19.95)         | Secondary sexual characters are well developed; females with ovigerous setae on the inner side of protopod of pleopods, males with a well developed appendix interna on the first pleopod and appendix masculine on the second pleopods, in females the endopod of the first pleopod tapers distally bearing setae. |

present study, in some of the laboratory reared animals' 5+5 or 5+6 and sometimes-even 6+6 dorsal spines were also observed.

To sum up, the larval development of *C. longirostris* passed through 8 zoeal stages, one intermediate stage and one postlarval stage. The postlarvae gradually grew for a period of 140 days and thereafter the growth rate reduced considerably. As the larvae attained total length of 17 to 20 mm, adult characters, including the development of secondary sexual characters were observed.

## Discussion

Complete or partial larval description of several species of *Caridina*, such as *Caridina wyckii* (Daday, 1907); *C. nilotica* (Gurney, 1927); *C. denticulata* (Shen, 1939); *C. laevis* (Nair, 1949); *C. propinqua* (Babu, 1963); *C. brevis* (Shokita, 1973); *C. weberi* (Chinnaya, 1974); *Caridina* sp. (Lakshmi, 1975); *C. pseudogracilirostris* (Pillai, 1975); *C. nilotica* (Glaister, 1976); *C. denticulata* (Shokita, 1976); *C. mccullochi* (Benzie, 1982); *C. singhalensis* (Benzie and de Silva, 1983); *C. babaulti* (Salman, 1987) and *C. gracilipes* and *C. prox* (Kadrekara and Sankolli, 1987) are available. Jalihal (1978) described four new species namely *C. williamsoni*, *C. kemp*, *C. gurneyi* and *C. shenoyi* from Dharwar area and studied their larval histories in detail.

Considerable variations are observed, in the duration as well as the sequence of development of various appendages,

among the different species of the genus *caridina*. *C. singhalensis* (Benzie and de Silva, 1983), *C. brevis* (Shokita, 1973) and *C. denticulata* (Shokita, 1976) exhibit a highly abbreviated larval development. In these species, well-developed pereopods and functional setose pleopods were observed even from the first stage. However, in species such as *C. wyckii* (Daday, 1907), *C. weberi* (Chinnaya, 1974), *C. williamsoni* (Jalihal, 1978) a prolonged larval development with 9 to 10 larval stages was noticed. *C. weberi* (Chinnaya, 1974) took 26 days to complete the larval development. In the case of *C. weberi* (Chinnaya, 1974) and *C. wyckii* pereopods and setose pleopods were observed only in the seventh or eighth larval stages. In between these two patterns of development, several species of this genus showed intermediate mode of development, with varying duration and sequence of development of thoracic and abdominal appendages. The newly hatched out zoea of *C. mccullochi* (Bebzie, 1982) metamorphosed to postzoea within 18 to 24 hours. The average duration taken to complete the larval development of *C. gurneyi* (Jalihal, 1978) was 3 to 4 days, *C. propinqua* (Babu, 1963) 4 days, *C. pseudogracilirostris* (Pillai, 1975) 9 days, *C. kemp* (Jalihal, 1978) 10 days and *C. nilotica* (Glaister, 1976) 12 days. In the sequence of appearance of various appendages, as well as in the duration of the larval development of the present species, *C. longirostris*, resemble with those of *C. williamsoni* (Jalihal, 1978) and *C. shenoyi* (Jalihal, 1978).

Rudimentary exopod of maxillule bearing plumose setae are noticed in the first two zoeal stages of *C. pseudogracilirostris* (Pillai, 1975), *C. longirostris* (present work), *C. babaulti* (Salman, 1987), *C. nilotica* (Gurney, 1927), and *C. williamsoni*, *C. kempfi* and *C. shenoyi* (Jalihal, 1978). Except in the case of *C. williamsoni* (Jalihal, 1978) where exopod bears 3 setae, in all other cases only 2 setae are noticed. In *C. pseudogracilirostris* (Pillai, 1975) and *C. longirostris*, these setae are retained in the first 3 stages, whereas in other species it is retained only for the first 2 stages. Larvae of *C. weberi* (Chinnaya, 1974), *Caridina* sp. (Lakshmi, 1975), *C. nilotica aurensis* (Glaister, 1976), and *C. gurneyi* (Jalihal, 1978) lack rudimentary exopod and plumose setae.

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